

# Assessment of Changes in Landcover and Landuse in Ebonyi State, Using Remote Sensing Technique

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## Abstract

This study shows a 31 years multi-temporal changes in landuse and landcover in Ebonyi State, Southeastern Nigeria. Since 1996 when the study area became a State, Ebonyi has experienced significant changes in its landuse and landcover as a result of its fast urbanization process. Based on the unique advantage that multi-temporal observation offers, landsat imageries of 1984, 2000, 2007 and 2015 were sourced and analyzed using Erdas Imagine 9.2 and ArcGIS 10.2 tools for the spatio-temporal changes in landcover extent and also rate of change from 1984 to 2015. This study was carried out essentially to draw attention of all stakeholders in the urban development sector for the need to restrict those negative adverse changes arising from urbanization that could be detrimental to the environment. Analysis of imageries revealed that the extent of built –up areas in Ebonyi State increased from 42074.39 hectares in 1984 to 212762.3 hectares in 2015 representing a percentage increase of 35.8487%. While swamp rice farms gained (15.6850%) however, vegetation cover lost as much as 48.4662% in the 31 years period the study covered. The decrease in vegetation cover was found to have been replaced by increases in built –up and swamp rice farms areas. The study however, concluded that adequate measure must be taken to curtail the rate at which vegetation is been exploited for human use as it could led to harsh adverse effect that could be detrimental to the environment. In addition, more people should be encouraged to plant trees so as to ameliorate the negative impact of these changes on the environment as well as humans. Institutions in charge of urban planning should also be strengthened for effective monitoring of urban expansion.

**Keywords:** Assessment; Landcover; Landuse; Ebonyi; remote sensing

## 1. Introduction

In recent times, there is being a growing need to assess the changes in the landscape of the earth. This assessment has become significantly necessary, due to anthropogenic activities of man that has greatly altered the natural state of the earth landscape. This alteration is largely due to numerous demands to which man has subjected the use of land to for his daily living. This in turn has caused changes in the land use and landcover of several places over time and space. The condition of land and its cover type in any particular area is a direct reflection of the natural and socio economic activities that is prevalent in the area and how man has put the land to use over time and space. As the needs and desire of man continue to be on the increase, the demands for land are also increasing. Consequently, this demand for land by man for several activities of man's endeavours is impacting on every aspect of the natural features of the earth surface e.g. wetland's, vegetation etc. Therefore information regarding changes in landuse and land cover has become very essential for proper planning and implementation for its optimal use so as to meet the demand for the basic need of man and also to maintain a balance on the environment. This information is necessary as it will help to monitor the dynamics of landuse as a result of increasing demand on it due to increasing population. Remote sensing datasets have become very essential in addressing critical issues that relate to how man's environment are managed, thereby giving a platform to researcher to make quick decisions for the benefit of man and the environment and also crucial for formulating effective environmental policies and management strategies (Kuleli, 2005). Change detection plays a critical role in presence of either large-scale evolution of areas at large time-scale or sharp sudden change after the occurrence of a natural hazard, particularly when considering urban environment with dense built-up areas (Park, Yamaguchi, & Kim, 2013). It is a very significant area in research as the time and precision of changes observed on the land surface allows for an in-depth comprehension of the interactions between man and the natural phenomena and can provide guidance in managing land and resources (Alqurashi, & Kumar, 2013). Change detection involves the use of multitemporal data sets to discriminate areas of land cover change between dates of imaging (Lillesand, Kiefer, & Chipman, 2008). Detecting changes in the environment involves the use of multiple data sets at different time frame with the view of analyzing its effects on phenomena (Lu, Mausel, Brondizio, & Moran, 2004); (Zoran, 2006). Using satellite imagery has been a very popular means of studying these changes since the early 80s, as it has helped in creating improvement in the assessment of changes in the environment. It has been applied in many important remote sensing applications including environmental measurement, forestry management (Forkuo & Frimpong, 2012), regional mapping and planning (Du, et al., 2012, (Hegazy. & Kaloop, 2015), agriculture (Kumar, 2012), geology (Nefeslioglu, Tun, Ayday, & Goktan, 2003), oil pollution monitoring (Liu, Du, Tong, Samat, Bruzzone, & Bovolo, 2017), surveillance (Van den Broek, Dekker, & Steeghs, 2005), widespread disaster measurement

(Xiong, Chen, & Kuang, 2012). A great number of these changes in the natural features of the earth surface are largely induced by man's activities for examples population increase, urbanization, shifting cultivation, animal grazing and some natural occurrences such as climate changes. . Major sources of data for studying these changes in the environment include Landsat, radar, Advanced Very High Resolution Radiometer (AVHRR), and Satellite Probatoire d'Observation de la Terre (SPOT). Landsat is one of the most frequently used remote sensing techniques to observe and monitor Earth surface changes is Landsat imagery as a result of its medium spatial resolution and its frequency in the collection of data (Huseyin, & Amir, 2018). Landsat multispectral and temporal imagery are important source of data for observing changes. This is because it has provided continuous coverage of the earth surface since the 1970s and contains bands that are sensitive to changes in vegetation coverage, soil moisture, wetlands etc. In Landsat satellites, the images are acquired using passive optical and multispectral sensors, so that this remote sensing technique is very sensitive to any meteorology conditions (Shi, Wu, Paul, Jiao, & Gong, 2014), (Roy, Zhang, & Ju et al., 2016). The earliest Landsat imagery dates to 1972 (Bauer, Yuan, & Sawaya, 2003), (Jensen, 2005). The use of remote sensing datasets thus provides a unique opportunity to characterize the spatio-temporal distribution of these changes (Pietroniro, A. & Töyr, 2002); (Dixon, & Candade, 2008) and to collect important baseline information that is too difficult to get when using field-based observation methods. Change detection methods in Landsat images are mostly based on supervised and unsupervised techniques (Yavariabdi, & Kusetogullari, 2017). However, the later approach is mostly used in change detection. Remote sensing imagery is an excellent tool for rapid mapping applications. In this context, one of the main uses of remote sensing is the detection of natural or anthropic changes (Renza, Martinez, & Arquero, 2013). The use of past images paired with more recent images can be useful in the detection of changes in the landscape over a period of time (Jensen, 2005); (Chen, Jing, Bo, Shi, & Zhang, 2007). This paper, therefore, apply the technique of remote sensing datasets in detecting changes in land use/land cover/ estimating the areal extent of the changes over the study area, as a means of providing relevant information to planning authorities and also assists in making decisions that could quickly and easily mitigate the unfavorable effects of the changes to man and the environment.

### 1.1 Study Area

Ebonyi State (Fig.1) is situated in southeastern zone of Nigeria. The State lies approximately within latitudes 5° 40' and 6° 45' North and longitudes 7°30' and 8°30' East. Ebonyi State has a population of 2.1 million [8]. The State has a landmass of approximately 5,935 square kilometres. Abakaliki is the State capital and also the biggest city. The second biggest town in the state is Afikpo which is located in the Southern border with Cross River State. It is one of the States in Southeastern Nigeria that is endowed with large area of swampland and is popular for the cultivation of swamp rice. The basic occupation of the people of Ebonyi is farming [4]. Ebonyi State is a major national rice market and also processing centre. Other crops cultivated in the State include: cassava, oil palm and groundnut. Ebonyi has several solid mineral resources, including lead, crude oil, and natural gas, but few large-scale commercial mining mines. The availability of these mineral resources has greatly influence the development and expansion of urban areas in the State.

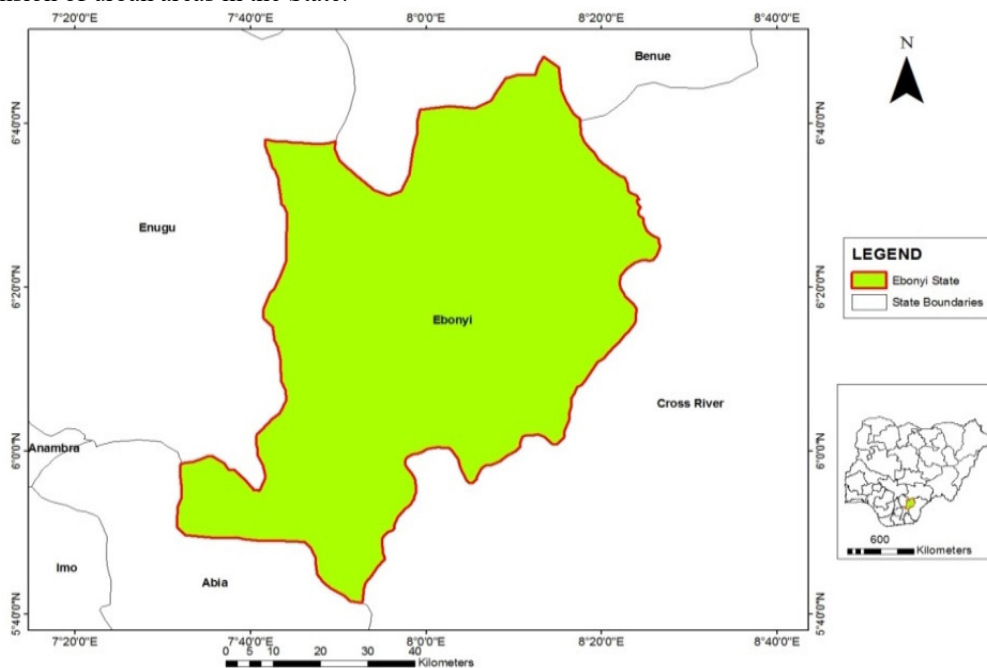


Fig. 1: Map of Ebonyi State, Southeastern Nigeria

In Ebonyi State, there has been a significant increase in the number of manufacturing and industrial sector, the State has various food processing factories which include dozens of rice mills, quarry factories, a fertilizer blending plant, and also one of the Nigerian largest poultry and one of Nigeria's foremost cement factories. The presence of educational institutions in the State such as the university in Abakaliki, a federal polytechnic, one college of education in Ikwo, a college of agriculture in Ishiagu and several secondary and primary schools spread across the various towns and villages in the state has also contributed to the growth of the State. The influence of human activities such as farming could also have affected changes in landcover.

### 1.1.1 Data Sources and Methodology

Landsat imageries of 1984 (MSS), 2000 (ETM+), 2007 (TM), and 2015 (TM), were sourced from United States Geological Survey (USGS) website and analyzed in order to obtain the required data for this work. Ground truth exercise was also carried out to ascertain what was on the imageries. Therefore, the decades considered were decades between 1984 - 2000, 2000 - 2007, and 2007 - 2015. These data sets were used in producing Landuse/Landcover map of the study area at different time periods, to be able to ascertain the changes that have taken place, and also predict changes that could have happen in the same area over time. The description of the satellite images are presented in Table 1. Landsat imageries of 1984, 2000, 2007 and 2015 aided the determination of the landuse/landcover classes. Supervised classification method was used to classify the imageries of each year into different areas. The changes in the areas between the decades were computed by using the classified imageries with areal extent. In this study, post classification method was chosen as it allows the use of legends in details. In Post classification method, imageries from various archives in different year interval are classified and labeled individually. This method helped in discovering the changes in areas extents and also the rate of change. ERDAS Imagine 9.2 version was used for the analysis of the Landsat imageries, including mosaicking, subsetting, layer stacking, and supervised classification of land classes and accuracy assessment of the classification. ArcGIS 10.2 was used to complement data processing. It was used for image enhancement. The use of ERDAS IMAGINE 9.2 software following the post classification method, helped in knowing the absolute area change and relative change of Landcover/ landuse classes. To calculate the changes of each LULC of each LULC classes to other LULC classes, LULC change matrix was done. Tables were prepared for change detection matrix that shows the change of one LULC to the other. The column of the table represents the final stage and the row represents the initial stage. Image differencing was applied from initial to final image. The negative indicator shows that the landuse/landcover is in a state of decrement while the positive indicator shows that there is an increment in LULC type. Calculations were done in hectares of the different land use types, such as Built-up areas, Vegetation and the Swamp rice farm. To achieve this, the classified image was displayed on a viewer. On the viewer menu, raster- attributes were also clicked to open add area column attributes with hectares as the default unit and area as the default name. The area in hectares was added to the attribute table. Analysis of changes was also performed on the images. The comparisons of the land cover statistics helped to identify changes in hectares/percentage, rate of change as well as trend between 1984 and 2015. Percentage change to ascertain change in trend was carried out by using division method which resulted to dividing observed change by sum of changes and a multiplication by 100

$$\text{Change in percentage (trend)} = \frac{\text{observed change} \times 100}{\text{sum of change}}$$

In getting the percentage yearly change rate, change in percentage was divided by 100 and multiplied by the years the study covers (i.e.) 1984 -2000 (6years)

$$(\text{Rate}) \text{ Percentage annual rate of change} = \frac{\text{Percentage change} \times 6}{100}$$

**Table 1: Description of Satellites imageries used for the study**

Satellite Imagery	Landsat Sensor(s)	Date of Acquisition	Path	Row	Spatial Resolution(m)
1984	L1-5 MSS	1984-12-13	188	55	30
1984	L1-5 MSS	1984-12-13	188	56	30
2000	L7 ETM+ SLC-on (1999-2003)	2000/12/01	188	55	30
2000	L7 ETM+ SLC-on (1999-2003)	2000/12/17	188	56	30
2007	Landsat 7(TM)	2007/12/01	188	55	30
2007	Landsat 7(TM)	2007/12/01	188	56	30
2015	Landsat 7(TM)	2015/12/17	188	55	30
2015	Landsat 7(TM)	2015/12/17	188	56	30

### 1.1.2 Results and Discussion

In this study, the imageries of 1984, 2000, 2007 and 2015 were evaluated and the obtained data in respect of the changes involved were summarized in Tables 2 ,3, 4, and 5. Classified images for 1984, 2000, 2007 and 2015 are

also displayed as Fig 3, 4, 5 and 6. Discussions were made under sub heading for better clarification.

#### **Discussion of changes in Landuse/ landcover between 1984-2000**

During the period of 1984 to 2000, built –up areas increased by 8525.22 hectares representing 16.85% increase with an annual rate of change of 1.011%. The swamp rice farm also increased by 28325.32 (49.52%) with an annual change rate of 2.97%. Vegetation however lost 36850.49 with an annual change rate of 0.46 representing - 7.59% decreases (Table 2). It is however, important to note that these increases gained were from vegetation cover. The built –up area experienced a lesser change compared to swamp rice farm (Table 2). Table 2 also revealed that Built up areas which initially occupied an area of 42074 hectares in 1984 increased to 50599.6 hectares in 2000. While swamp rice farms increased from 28871.65 in 1984 to 57196.97 by the year 2000. However, vegetation decreased from 522555.04 hectares to 485704.56 hectares in 2000. As at 1984, the study area was under Enugu State and part of Abia State; its creation came from the old Abakaliki section of Enugu and old Afikpo area of Abia State. It was a very significant section of the old Enugu State and Abia State. The area was primarily an agricultural community with very few commercial, educational institutions and industrial sectors. Historic site found in this area as at this time includes the uju Hill located at Abakaliki, Oferekpe Waterfall at Ikwo and the rock formations at Akpoha in Afikpo-North Local Government Area. Educational institutions include the Akanu Ibiam federal polytechnic, college of Agriculture and few other secondary and primary schools. Other important areas were the Ebonyi State teaching hospital, the general hospital at Onueke the Mater Misericordiae School of nursing at Afikpo before 1984. The presence of these institution made the study area very prominent among the surrounding communities. The study area had abundant cultivable land, economic trees and large areas of forested land. The study area played host to a wide variety of animals such as rabbits, squirrels, hawks and different types of monkeys etc. Ebonyi area was very rich in biodiversity. The basic economic activity dominate during this time of 1984 was mainly agriculture. The few other economic activities were concentrated at Abakaliki area. The main crops produced in the State are rice, yam, palm produce, cocoa, maize, groundnut, plantain, banana, cassava, melon, sugar cane, beans, fruits and vegetables. Fishing was also carried out in Afikpo. This explain why the finding from this study as shown in Fig 3 and table 2 revealed less built up areas as at 1984.

#### **Discussion of changes in Landuse/ landcover 2000 – 2007**

From Table 3 it is very obvious that built up areas have appreciated from 50599.61 hectares to 55559.99 hectares from 2000 to 2007 with annual change rate of 0.63% representing 8.93% increase with a total increase of 4960.38. This is an indication of gradual expansion of the city which has started to take place with the influx of people into the State as a result of being made a State capital with more built up areas being erected to accommodate more people. Swamp rice farms also increased by 18359.05 hectares with 1.70 % increase annually with 24.30% change. While vegetation further decreased by -23319.48 representing -5.04% decrease with an annual rate of change of 0.35%. Table 3 also revealed that built up areas which occupied an area of 50599.61 hectares in 2000, increased to 55559.99 by 2007. Swamp rice farms increased from 57196.97 hectares in 2000 to 75556.02 hectares by 2007. The decreases in vegetation cover continued with a further decrease from 485704.55 hectares in 2000 to 462385.07 hectares by 2007. By 2000, which was just four years after the area was created as State significant changes in the landuse/ landcover has started to take place as revealed by figure 4 and table 3. With the new Status of the study area, came increase in more economic, industrial and commercial activities. From here changes in built up areas appreciated from 50599.61 hectares to 55559.99 representing 8.935% increase, swamp rice farms also appreciated by 24.30% while vegetal cover was already negatively being impacted on with a loss of -5.04%. By this period, the State has started experiencing a lot of political, social and developmental activities. More industries and factories were established including dozens of rice mills. It was about this period that the college of education at Ikwo was founded. These activities made the State attractive to neighbouring communities hence the increase in the number of built up areas revealed in the study within this period (Fig.5).

#### **Discussion of changes in Landuse/ landcover 2007- 2015**

During this period shown in Table 4, built –up areas increased by 157202.31 hectares representing 73.89% increase with an annual rate of change of 5.91% which is the highest changes observed through -out the study period. Vegetal cover also decreased by -174737.98 hectares representing (-60.75%) change, also swamp rice farms gained 17535.67 hectares with 18.84% change. This period between 2007- 2015 showed remarkable changes in the landuse/ landcover status of the state as revealed by the study in figure 5 and 6. The result in Table 5, indicate that built –up areas in Ebonyi State increased from 42074.39 hectares in 1984 to 212762.3 hectares in 2015 representing a percentage increase of 35.8487%. While swamp rice farm gained (15.6850%) however, vegetation cover lost as much as 48.4662% in the 31 years period the study covered. The direction of change was basically losses from vegetation cover to either built-up or swamp rice farm ( Fig. 6) .By this period, the effect of the State capital has started attracting the establishment of more manufacturing industries in and around the State especially with the incentive given by the government of Ebonyi State to agro- allied sector. The State by this time has become one of the biggest rice- producing States in Nigeria. The State now has the highest number of rice mills in the whole of West Africa. These factors combined have encouraged the constant flow of people from neighbouring communities to Ebonyi State in search of better living opportunities. As good as this may sound, the development



of the State is creating adverse negative impact on the vegetal cover as revealed by the study with a -60.755 loss in vegetal cover within the period of the study. In recent times, due to the uncontrollably activities of man in the area which has impacted seriously on the vegetal cover of the study area, the area is now known to have less biodiversity and wildlife which has prompted the ministry of agriculture to have a reserved area in the zone in order to avoid the extinction of certain animals that are indigenous to the State. The rich flora and fauna of the study area is also facing extinction due to great loss of habitats. Many notable animals known to have existed in the area in the past have disappeared recently due to increased human impact on the ecosystem. Worthy of mention here is the fact that many notable economic species of trees that are indigenous to this area are also disappearing or declining in population from this once rich ecological zone. The forest area are shrinking so fast as large expanse of forest are been cleared away for various uses by man thereby exposing the earth. This situation became more severe after the State was created in 1996 as the creation brought about much inflow of people and economic activities to the State which brought cause-effect responses on vegetal cover as the need for more urban areas increased. The increasing population of the State as a result of the State creation brought about increased in demand for more land for industries and economic activities which in turn affected vegetation by way of increased exploitation by man for his daily comfort. Worthy of mention is the incidence of flooding which is becoming a yearly occurrence in the State ravaging the State and destroying houses in different communities resulting to death of individual and also ravaged farmland and destroyed crops worth millions of naira. The study area has increasingly become prone to environmental hazard of recent. Therefore, adequate measure must be taken to curtail the rate at which vegetation is been exploited for human use as it could be one of the likely causes of flooding in the area and other negative adverse environmental conditions.

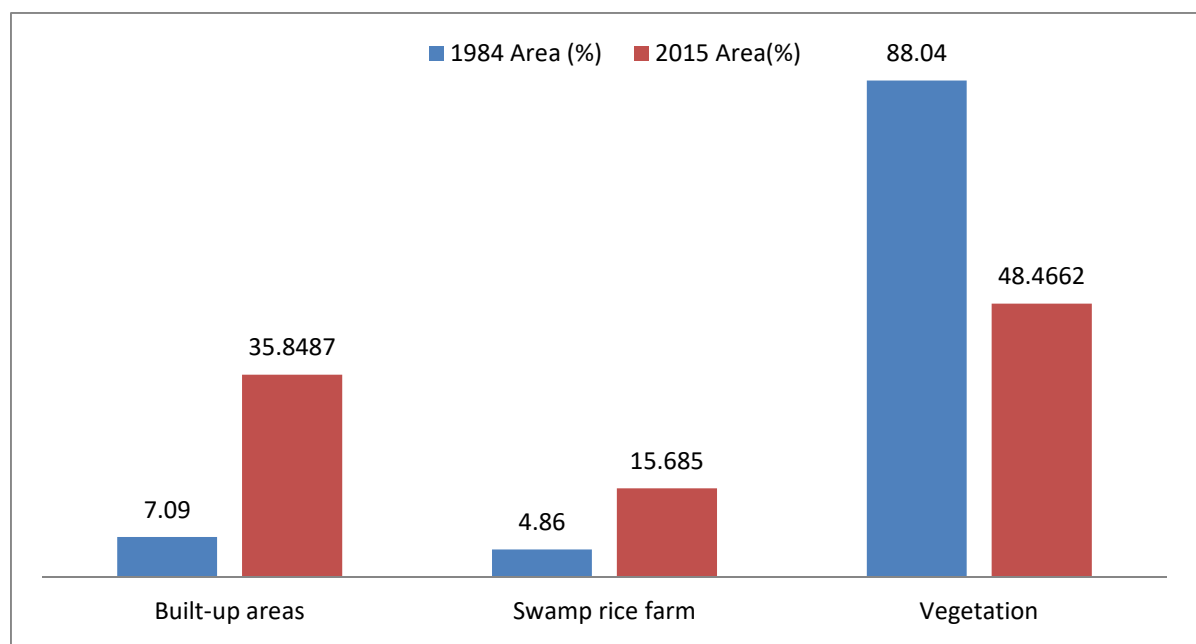
### 1.1.3 Conclusion and recommendation

The change detection covered a period of 31- years, beginning from 1984 to 2015. . The result of the work shows a rapid growth in built-up land between 1984 to 2015 as seen in maps and analysis carried out .The study revealed that other land use such as built-up and swamp rice farms has greatly impacted on vegetation cover reducing it from 522555.04 hectares in 1984 to 287647.09 in 2015 representing (48.4662 %) reduction. The dramatic changes in the spatio- temporal pattern of land use and land cover of the state especially in the increase in built-up areas could be attributed to its creation as a state in 1996. In this study, our emphasis was to detect the changes in landuse and landcover in Ebonyi State, Nigeria with a view of estimating the rate of changes that has taken place in the State over time. This was done with the aim of providing relevant and recent information, especially as it relate to the issue of development and the changes that has occurred in the natural features of the environment over time. Importantly, is the fact that information of this nature will assist in the formulation of effective environmental policies and management strategies for the well -being of the citizens. This study will also equip planners in the urban sectors with relevant information that would enable them to promptly address the negative effects of these changes. This study however, recommended that in order to preserve our vegetation more people should be encourage to plant trees so as to ameliorate the negative impact of these changes on the environment as well as humans. Institutions in charge of urban planning should also be strengthened for effective monitoring of urban expansion.

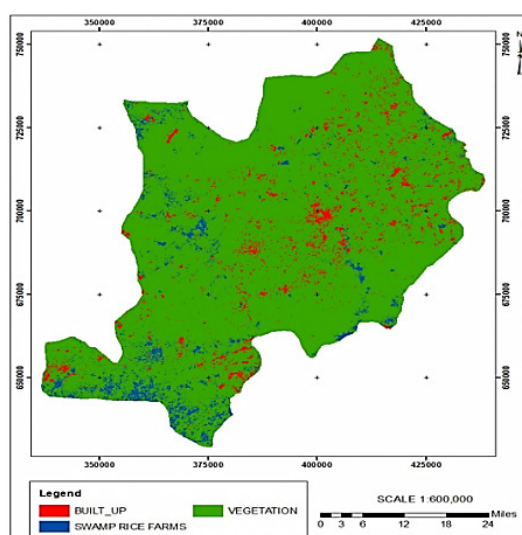
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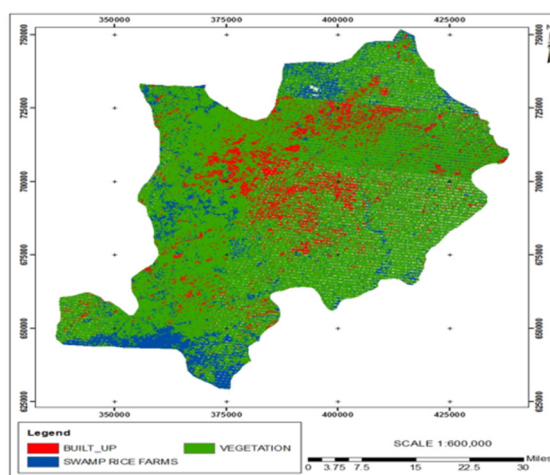
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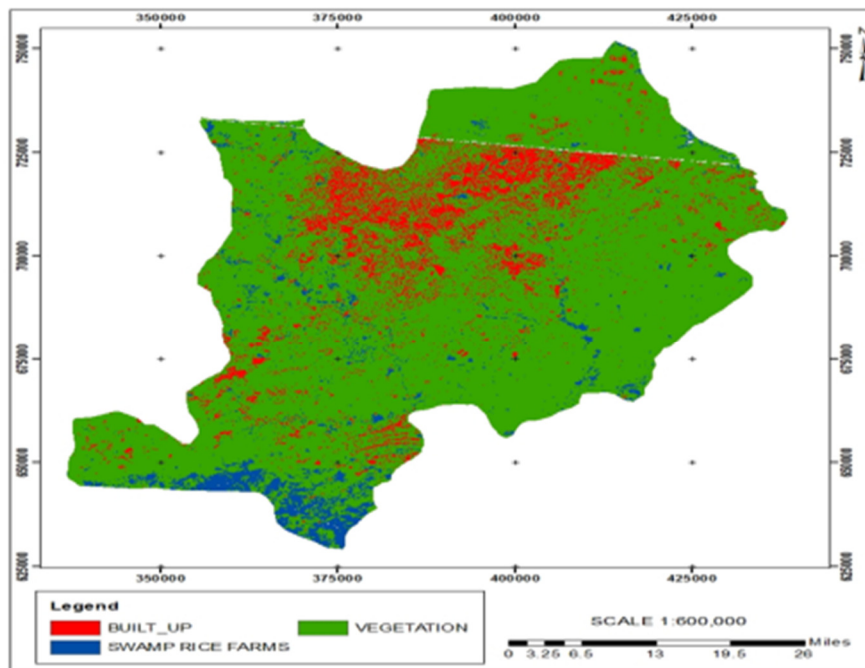
**Fig.2: Changes in landuse from 1984 to 2015**



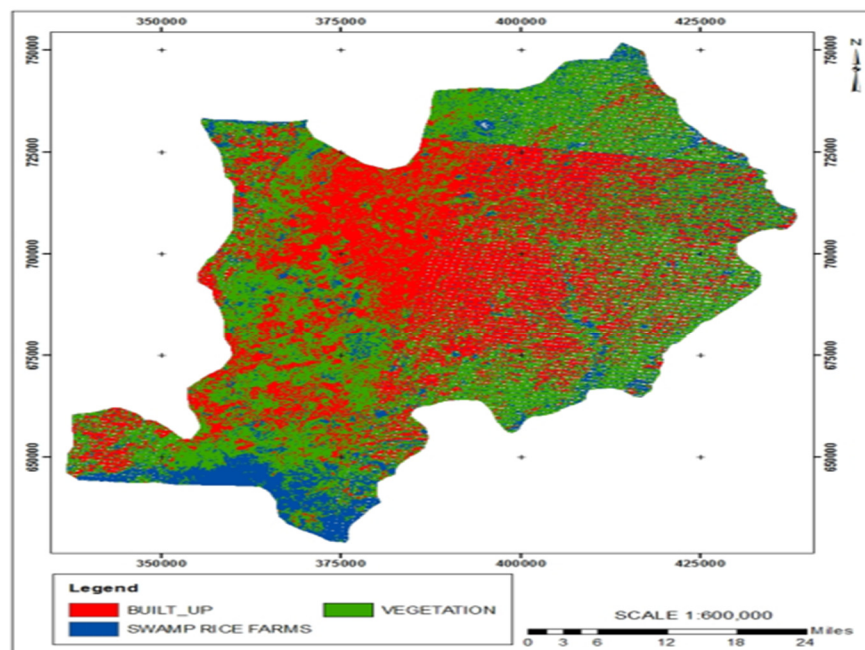
**Fig.3: Classified Satellite image of Ebonyi State, 1984**



**Fig. 4: Classified Satellite image of Ebonyi State, 2000**



**Fig. 5: Classified Satellite image of Ebonyi State, 2007**



**Fig.6: Classified Satellite image of Ebonyi State, 2015**

**Table 2: Land Cover Change, Magnitude, Trend, Rate and Direction**

S/N	LANDUSE TYPE	AREA (hectare)		Increase (+) Decrease (-)	Change in %	Annual rate of change in %
		1984	2000			
1	Built-up areas	42074.39	50599.6	8525.22	16.85	1.011
2	Swamp rice farm	28871.65	57196.97	28325.32	49.52	2.97
3	vegetation	522555.04	485704.55	-36850.49	-7.59	0.46



**Table 3: Land Cover Change, Magnitude, Trend, Rate and Direction**

S/N	LANDUSE TYPE	AREA (HA)		Increase (+) Decrease (-)	Change in %	Annual rate of change in %
		2000	2007			
1	Built-up areas	50599.61	55559.99	4960.38	8.93	0.63
2	Swamp rice farm	57196.97	75556.02	18359.05	24.30	1.70
3	vegetation	485704.55	462385.07	-23319.48	-5.04	0.35

**Table 4: Land Cover Change, Magnitude, Trend, Rate and Direction**

S/N	LANDUSE TYPE	Increase (+) Decrease (-) (2007-2015)	Change in %	Annual rate of change in %
1	Built-up areas	157202.31	73.89	5.91
2	Swamp rice farm	17535.67	18.84	1.5
3	vegetation	-174737.98	-60.75	-4.86

**Table 5: Land Cover Change, Magnitude, Trend, Rate**

Year	1984		2015	
	Size of area	Area (%)	Size of area	Area(%)
Built-up areas	42074.39	7.09	212762.3	35.8487
Swamp rice farm	28871.65	4.86	93091.69	15.6850
Vegetation	522555.04	88.04	287647.09	48.4662